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PACIFIC SOUTHWEST
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RESEARCH
NOTE

U. S. D[illegible] T. [illegible] CULTURE
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FEB 16 1961
CURRENT SERIAL RECORDS

No. 168)

5c
September 1960

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DRYING RATE OF WHITE FIR BY SEGREGATIONS

By

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Harvey H. Smith[1] and John R. Dittman[2]

In the spring of 1959 the Pacific Southwest Forest and Range Experiment Station and the Winton Lumber Company began a cooperative study of the drying of white fir at its Martell, California, plant. This is a report on experimental kiln runs made to study the drying rate of white fir segregated by type of wood. A previous study showed that commercial segregation is not clear cut, primarily because of difficulties in placing boards with two or more types of wood. [3]

At mills where the volume of production makes segregation practical, white fir is often separated into three sorts for drying: cork, sap, and sinker. The sorting is based on properties of the wood that affect the drying. When the types are segregated, each kiln charge can be made up of material with uniform drying characteristics, and the kiln schedule can be adjusted according to the requirements of the particular type of lumber. The results are shorter drying time and more uniform final moisture content of the kiln dried lumber.

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[1] Forest Products Technologist, Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

[2] Sawmill Superintendent, Winton Lumber Company, Martell, California.

[3] Smith, H. H. and Dittman, John R. The segregation of white fir for kiln drying. U. S. Forest Serv., Pacific Southwest Forest and Range Expt. Sta. Res. Note 167, 6 pp., illus.

OBJECTIVES

The objectives of this study were: (1) To determine the green moisture content of white fir by segregations, (2) to determine the drying time for each type of white fir when dried by schedules now used commercially and known to be acceptable, (3) to study methods of reducing drying degrade.

PROCEDURE

The kiln runs were made in a small demountable, steam heated, internal fan kiln built at the U. S. Forest Products Laboratory, Madison, Wisconsin. [4] The kiln is located at the research laboratory of the California Cedar Products Company, Stockton, and is being operated in cooperation with that company. This kiln will hold approximately 500 board feet of 4/4 lumber in a load 4 feet wide, 4 feet high, and 8 feet long.

This experimental kiln is equipped with a recorder-controller for maintaining the drying conditions as called for in the drying schedule. It is equipped with two fans, but in this study only one fan was used so that the air velocity through the loads would be similar to the circulation through commercial kilns. With one fan operating, the airflow measured at the leaving-air side was 475 to 500 feet per minute. Some of the seven runs dried in this study did not load the kiln to capacity; the runs ranged from 432 board feet to 608 board feet of 1 7/8-inch lumber.

Selection of the test material was of primary importance. Test material consisted of 1 7/8-inch x 12-inch x 16-foot planks, selected at the green chain with the help of the company grader who marks green white fir for pulling into drying segregations. Each 16-foot plank was cut into two 8-foot planks for drying in the small experimental kiln.

COMMERCIAL SORTS

The first two runs were "sap" segregation, as marked on the green chain by the company grader, and can be classed as "commercial sorts." Each plank was predominantly sapwood, but could include narrow streaks of sinker-type wood or small to fairly large areas of cork-type wood. Segregation on the green chain is based primarily on the judgment of the grader. Therefore a certain latitude for error is present and is considered normal under production conditions. These planks were typical of the sap segregation dried in the dry kilns at the Winton plant.

The schedules used were similar to or slightly more mild than commercial schedules for this type of stock. The progress of the drying was followed by using 16 kiln samples cut from representative material.

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[4] FPL report No. R1671, "Small Demountable-Type Lumber Dry Kiln for Experimental Drying."

These two runs supplied data on the drying time for a commercial sap segregation but not for true sapwood free of all cork or sinker-type wood. The need for more careful selection of the test planks was indicated. To minimize the chances for variation due to human judgment, the responsibility for selecting and grading the test material was placed with the head grader.

PURE SORTS

In all runs after the first two, the test material was selected to represent "pure" sorts. Each plank of any one type was virtually 100 percent that one type of wood. "Cork" planks were all cork; "sap" planks were all sap, etc. In these five runs, the drying rate of each type of wood was determined. Some runs included more than one type. The method of kiln operation was effective for experimental drying, but not suitable for commercial drying.

Run No. 3

The third run contained all three segregations. The following procedure was used: Fifteen planks of 1 7/8-inch x 12-inch x 16-foot white fir were selected from the green chain that were as nearly as possible "pure sorts," to make up a kiln charge of:

10 pcs.	1 7/8 x 12 inches	8 feet long	cork
10 pcs.	1 7/8 x 12 inches	8 feet long	sap
10 pcs.	1 7/8 x 12 inches	8 feet long	sinker

Two kiln samples were cut from each of three 8-foot planks of each segregation. The kiln samples were 42 inches long. The moisture content of sample boards was determined by the standard ovendry method.

The 8-foot planks were piled into the kiln, 4 wide per course, with the sinker segregation on the bottom, then the sap, and the cork segregation on the top. The kiln samples were piled on top of the 8-foot planks and the whole load baffled. One and one-quarter-inch x 2-inch x 52-inch stickers were used--5 per course.

The moisture content of the samples was followed during the drying cycle by periodic weighings. Shortly after the cork samples had dried to a moisture content below 20 percent, both samples and 8-foot planks of cork type were removed from the kiln. The sap samples and planks were also removed as soon as practical after they had dried below 20 percent.

When the sinker samples had dried to a moisture content below 20 percent, all the cork and sap samples and planks were repiled into the kiln. The charge was equalized at 180° F. dry bulb - 165° F. wet bulb for 26 hours and conditioned at 180° F. dry bulb - 170° F. wet bulb for 9 hours (fig. 1).

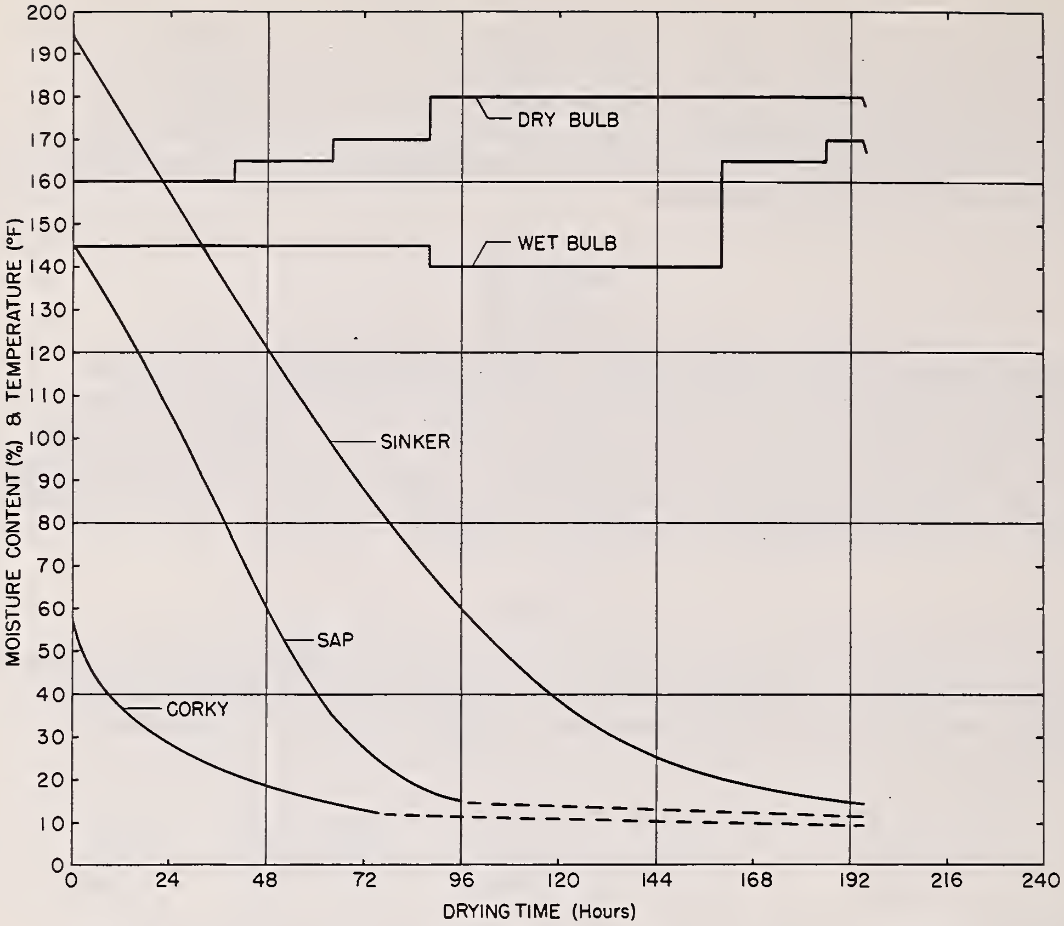

Figure 1.--Kiln schedule and drying curves for three types of white fir.

The 8-foot test planks were regraded rough-dry, and again after surfacing.

Runs Nos. 4 and 5

The next two kiln runs were made to learn more about the drying rate of cork- and sap-type wood and thus determine what improvement in drying time of these two types could be gained by using somewhat more severe kiln schedules. Each charge was made up of cork- and sap-type planks selected at the green chain to represent as nearly as possible "pure" sorts of each segregation. The experimental material in the two runs was not matched and the slight differences in drying time that resulted can hardly be attributed to the schedules alone (fig. 2). The test material and the kiln samples of the two sorts were piled in the kiln in a manner similar to the handling of the different sorts in run No. 3.

The test pieces were regraded rough-dry, and again after surfacing.

Run No. 6

Only sinker-type material was dried in run No. 6. The schedule and operation of the kiln were almost identical to that used in run No. 4.

The kiln dried lumber from run No. 6 was resawed after surfacing and regrading. Some internal checks were exposed, indicating that the schedule used was probably more severe than can be used for drying sinker-type wood without danger of some degrade.

Run No. 7

The seventh kiln run was dried to check results obtained in run No. 6. The schedule used was again almost identical to that used in run No. 4. Sap material was also included in this run. The drying rate was

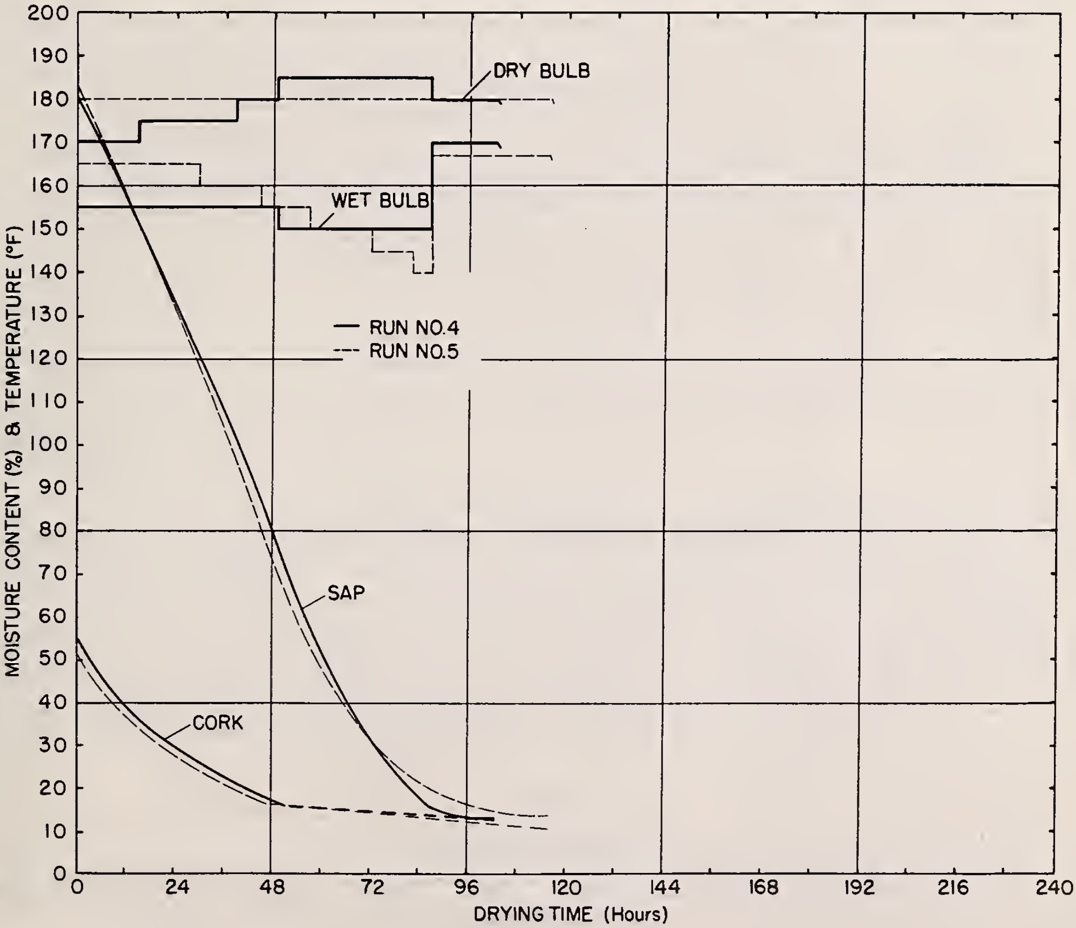

Figure 2.--Two kiln schedules and drying curves for two types of white fir.

determined by kiln samples as in all previous runs. The total drying time to a final moisture content of 20 percent was longer than for run No. 6 (fig. 3). Since it was virtually impossible to match the test material, this difference of 20 hours may be attributed to differences in the test material in these two runs. The green moisture content of all sinker samples in run No. 7 was 12 percent higher than in No. 6.

GRADING

The head grader graded all test lumber at the green chain, again after kiln-drying, and finally after surfacing. Though only reasonable commercial schedules were used in this series of seven kiln runs and no serious drying degrade was anticipated, this grading procedure was used to measure the general quality of the drying. In most of the runs almost half of the test material was used for kiln samples, leaving a relatively small number of 8-foot planks for regrading. The degrade figures, therefore, are at best only a rough check or indicator.

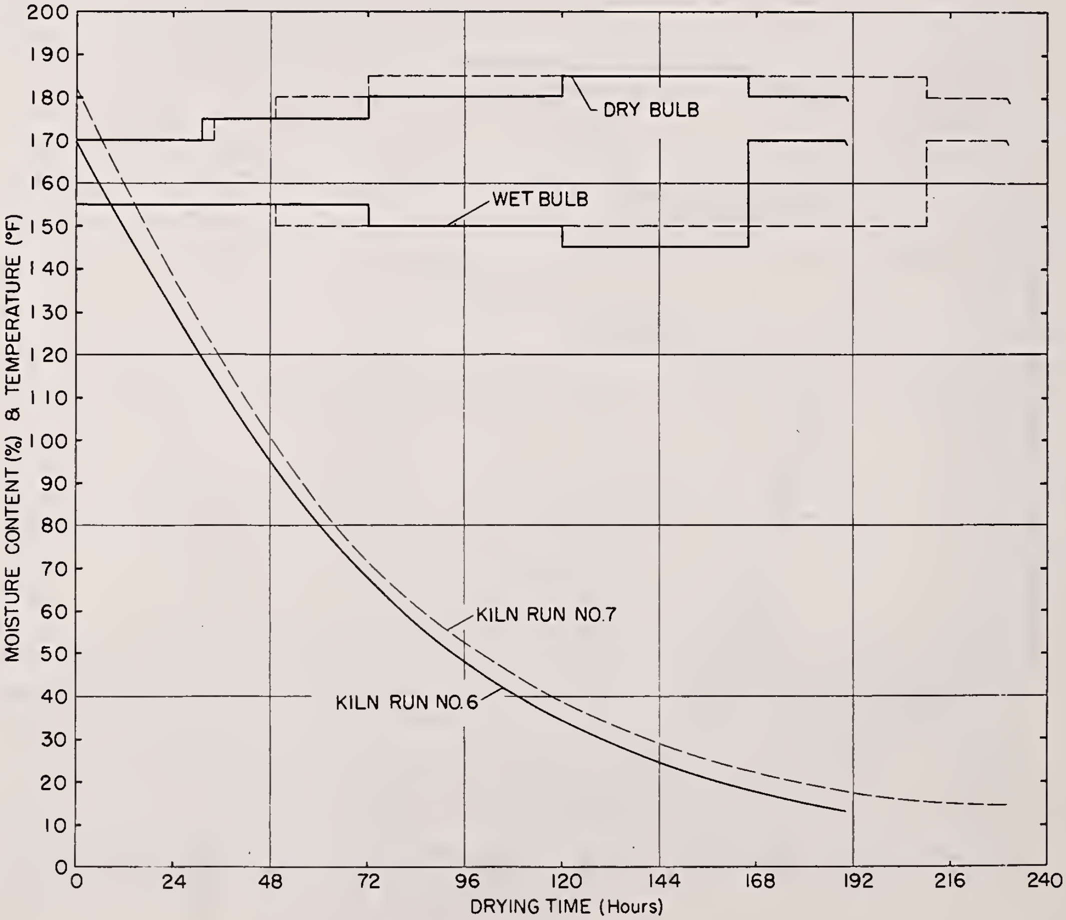

Figure 3.--Two kiln schedules and drying curves for sinker-type white fir.

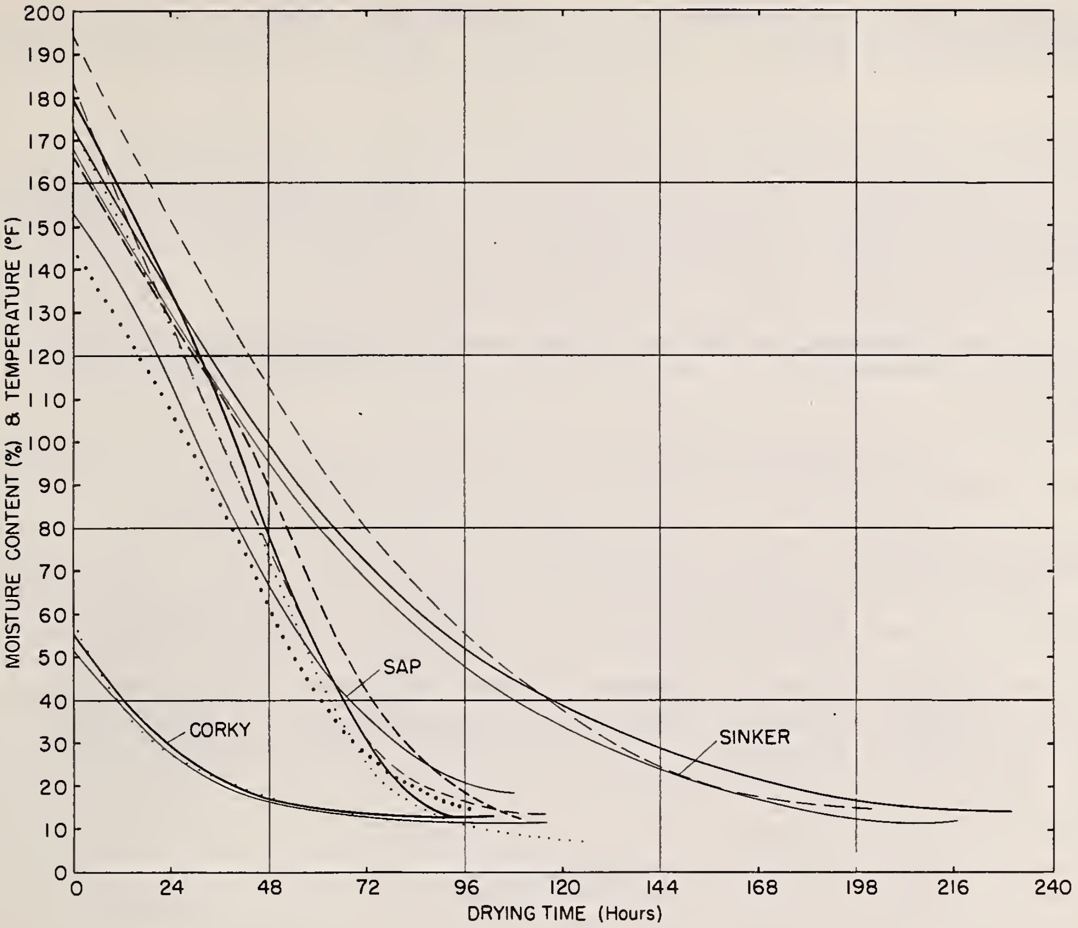

Figure 4.--Drying curves for cork, sap, and sinker-type white fir in seven experimental kiln runs.

The way lumber is kiln-dried affects the degrade that develops during surfacing because of cracked and brittle knots, cup, steep moisture gradient, etc. Degrade during surfacing is also very closely associated with the extent of drying or moisture content at the time of surfacing. In making these seven experimental kiln runs, the drying was not always terminated when each segregation had reached 20 percent. The degrade that developed during kiln drying is therefore more accurately reflected in change of grade from green to rough-dry.

RESULTS

MOISTURE CONTENT

The green moisture content, as determined in preparing the kiln samples, varied greatly between the three sorts, from 50 to 60 percent for the cork (average 55.1 percent), 145 to 180 percent for sap (average 170.3 percent), and 170 to 195 percent for sinker (average 181.3 percent). These moisture ranges were materially greater than the range measured in commercial sorts. [5]

DRYING TIME

The most striking results were (1) the uniformity of drying time within each of the three types of wood, regardless of the schedule used, and (2) the extreme difference in drying time between the three types (fig. 4).

An examination of the drying curves shows the drying time of sap to be twice that for cork, and for sinker twice that for sap (table 1).

Table 1.--Drying time in hours to 20 percent moisture content

Kiln run	Segregation			Range of kiln conditions	
	Cork	Sap	Sinker	Start D.B.-W.B. Dep.	Finish D.B.-W.B. Dep.
	Hours	Hours	Hours	Degrees F.	Degrees F.
[1] 1	--	102	--	160-7	180-40
[1] 2	--	114	--	160-15	180-40
3	42	84	158	160-15	180-40
4	42	82	--	170-15	185-35
5	39	86	--	180-15	180-40
6	--	--	156	170-15	185-40
7	--	78	176	170-15	185-35
Average All runs	41.0	91.0	163.3		
Average "Pure sorts"	41.0	82.5	163.3		

[1] Commercial sap segregation.

DEGRADE

Much of the lumber in these seven experimental kiln runs was dried to a lower final moisture content than is desirable for machining dimension lumber. The average final moisture content of all test material was 12.1 percent when surfaced, ranging from 8.6 percent for sap in run No. 7 to 14.4 percent for sinker in run No. 3.

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[5] Smith, H. H., and Dittman, John R. *op cit*.

The regrading of the 8-foot cork planks showed that no degrade developed during kiln drying, but some degrade was present in both the sap and the sinker-type planks. Reasons for degrade were split and loose knots, checks or splits, warp (cup), and shake. These defects are associated with the overdrying of dimension lumber as well as the kiln schedule used. There was no measure of the kiln drying degrade at a final moisture content of 15 to 20 percent, which is considered desirable for surfacing dimension.

Internal checks (honeycomb) developed in run No. 6 but were revealed upon resawing rather than by surface examination alone.

Severe degrade developed during surfacing, owing primarily to planer splitting. Cork lumber, for instance, which showed no degrade as rough-dry, showed roller-splitting in more than half of the 8-foot planks when surfaced.

The degrade figures serve as a rough check on the schedules used, but fall far short of the accuracy one would expect from a study to determine degrade. Another part of the study plan is designed to determine losses resulting from remanufacture (surfacing) of overdry stock.

CONCLUSIONS

The green moisture content of white fir varies greatly from the low moisture content cork-type wood to the high moisture content sap and sinker-type wood.

Because of the great differences in green moisture content and differences in drying rate between sapwood and heartwood, the three segregations of white fir require greatly different drying time. The ratio is very close to 2 - 4 - 8 for cork, sap, and sinker, respectively. The difference in drying time of the three segregations clearly indicates the need for accurate segregation on the green chain if a small range of final moisture content is necessary.

A mixed charge of all three segregations, dried to the requirements of the sap segregation, would have a range of final moisture content of 4 to 6 percent for the cork; 15 to 20 percent for the sap; and 55 to 65 percent for the sinker. Similarly, a mixed charge of all three segregations, dried to the requirements of the sinker, would greatly overdry the cork and the sap segregations. Both would approach final equilibrium moisture content conditions, or an estimated 4 to 6 percent moisture content when the sinker had dried to a final moisture content of 15 to 20 percent.

The drying time of any one segregation of white fir was not greatly affected by the range of drying schedules used in these experimental kiln runs. The results affirm the recommended schedules of the Forest Products Laboratory as shown in report 1791. There appears to be little advantage in changing these schedules to further reduce the drying time.

Regrading the study lumber after drying also indicated that the schedules are satisfactory, particularly for cork and sap-type wood. Overdrying, on the other hand, may cause some loss of grade as measured in rough-dry lumber, and considerable degrade during remanufacture as measured in the surfaced-dry lumber.

The somewhat milder schedules recently recommended by the U. S. Forest Product Laboratory 6/ are more suitable for sinker-type white fir Shop and Molding grades and other items where drying defect greatly reduces the value of the finished lumber.

Accuracy in marking white fir on the green chain for pulling into drying sorts will greatly facilitate kiln drying to a uniform final moisture content. If boards contain two or more types of wood, parts of them will be overdried or underdried, as the results of this study clearly show. How best to segregate these problem boards will depend on the moisture content requirements for remanufacture and final use. Since not all sections of these boards will be uniformly dried by the usual commercial kiln drying procedure, each board should be marked to reduce the dollar loss due to overdrying or underdrying. To prevent overdrying of dimension-type boards, they are usually segregated into the sort indicated by the faster drying type of wood. Shop-type boards, which must be dried to lower moisture content than dimension, are usually segregated into the drying sorts indicated by the slower drying wood.

Studies of the effect of moisture content on economic losses during remanufacturing would be a fruitful line of investigation to aid in segregation of drying sorts.

6/ Kiln schedules and drying time, U. S. Forest Products Laboratory report No. 1900-5, March 1960.